NASA Research Grant NsG 237-62

The Semiannual Report for the Period

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I N D E X

INTRODUCTION

UCLA has administered a NASA grant in support of space-related research in the physical and biological sciences and engineering for approximately four years. This report covers the activities supported from NASA Research Grant NsG 237-62 for the past six months.

A section of the report is devoted to a summary of the financial details of the grant. It is again emphasized that this section is not an official accounting report, which must, of course, be made by the Accounting Office. However, the summary herein given is a very good approximation of the total expenditures, future commitments, and current balance.

FUNDAMENTAL PROBLEMS IN ASTRONOMY
L. H. Aller   Account No. 448610

Calculation of Recombination Coefficients and Balmer Line Intensities in a Highly Ionized and Attenuated Hydrogen Plasma

L. H. Aller
W. H. Clarke

Mr. Clarke has taken advantage of the sophisticated modern computational techniques to develop theoretical methods for computing the $b_{n,\ell}$ factors, describing the departure from Boltzmann distribution for a plasma at an electron temperature T_ε. The methods are sufficiently general that they can be modified by a straightforward procedure to handle carbon and other elements.

The essential problem lies in the calculation of transition probabilities for large numbers of radiative dipole transitions between bound states characterized by quantum numbers, (n,ℓ) and $(n', \ell+1)$ or $(n', \ell-1)$ and between bound states and free states in the continuum, where the distribution of velocities follows a Maxwellian distribution law.

The project is now rapidly nearing completion. Owing to the wide range of quantum states treated, new techniques of computation have had to be devised and carefully examined for numerical stability, but it now appears that all the required procedures are in working order and that the final calculations for hydrogen can be carried out.

Following this, the calculations for carbon will be made.

24" TELESCOPE FOR PLANETARY AND STELLAR OBSERVATIONS
L. H. Aller   Account No. 448621

The 24-inch telescope purchased from the California Institute of Technology was assembled essentially in two stages. The mounting which included the polar axis assembly, fork unit, center gimbal, and declination worm gear was installed at Ojai, California, in a permanent observatory on April 21,

1965. The remainder of the instrument was assembled on May 29, 1965. A 6-inch guide telescope was mounted on the main instrument along with a projection reticle system to aid in star tracking. Independent focusing mounts were built and adapted to the telescope so that focusing could be accomplished without disturbing the secondary mirror. At present, it is being used for visual and photographic work for which special plateholders were constructed. Future additions include a photoelectric photometer which will be completed this fall. In addition, spectrographic equipment has been ordered, and investigations are being made into the possibility of obtaining a scanning spectrophotometer. Primary work will involve photoelectric and spectrographic rather than photographic studies.

The telescope is situated at an altitude of about 1500 feet overlooking a valley; seeing conditions are good most of the year. The telescope is in operation now and will be in full operation when the photoelectric photometer is completed and installed at the site. Spectrographic work is expected to commence early next year.

ORGANIC CHEMISTRY
R. Berger   Account No. 448604

The investigations into the composition and mode of formation of thucholites was continued. Additional carbon isotope ratio measurements were carried out. Values of lighter than -40 per mil with reference to the Peedee belemnite standard were obtained. Comparison with coal-derived gases which are generally in the -20 to -30 per mil class excludes the possibility that thucholite was formed from coal. Another class of carbonaceous materials found in nature has C^{13}/C^{12} isotope ratios of lighter than -60 per mil. These substances are regarded to be due to bacterial action. Therefore, the formation of thucholite cannot be ascribed to a biogenic origin on the basis of its C^{13}/C^{12} isotope ratio and its origin in pegmatite.

Additional analyses are being carried out, especially

to correlate North American thucholites with those found in the Witwatersrand in South Africa.

During the summer, the Isotope Laboratory participated in the Summer Study Program in Geochemistry for Undergraduates. Miss Nora Lesser, University of Chicago, worked on the synthesis of polypeptides, and Mr. Robert Sherman, Whittier College, California, worked on the turnover rate of organic soil constituents.

SOLID STATE PHYSICS

Crystal Growing Laboratory
H. E. Bömmel   Account No. 448604

Progress during the report period was extended in the following areas of the crystal growing effort.

1. **High Pressure Apparatus**
   The high pressure phase of thallium was obtained and recovered at atmospheric pressure. Examination of the properties of the specimen included the measurement of the superconducting transition temperature and critical magnetic field. Present work is directed toward the problem of growing single crystals at high pressures with indium antimonide as current working substance.

2. **Bridgeman Furnace**
   A Bridgeman furnace was designed, constructed and successfully employed to grow single crystals of metals among which are the following: lead with europium as impurity for the study of gapless superconductors; magnesium with various rare earths as impurities for the study of localized moments; and indium crystals for acoustic nuclear magnetic resonance studies.

3. **Induction Furnace**
   An induction furnace is on order and will be employed to grow high purity single crystals of the refractory

metals as niobium and tantalum.

With the addition of the third item the laboratory will
contain many of the basic facilities for a beginning crystal
growing effort. Also, many of the necessary auxiliary
facilities are in operation or are accessible, such as an
x-ray apparatus, a spark erosion cutter and a lapp and polish-
ing facility.

ROCKET PROJECT

P. J. Coleman, Jr.   Account No. 448626
U. Fehr
B. Ben-Ary

This project is concerned with experimental studies of
the propagation of disturbances in the ionized regions of
the magnetosphere. To facilitate these studies, we hope
to develop relatively sensitive magnetometers and acoustic
detectors that can be operated at the earth's surface, in the
atmosphere at various altitudes, and in the ionosphere at
altitudes that can be reached by sounding rockets.

During the reporting period, the experimental program
at Point Mugu was continued. This program included a
series of tests in each of which an array of pressure sensors
(Moore Variometers) was employed to record the pressure
disturbances created by rocket vehicles between the time of
launch and the time the vehicle reached an altitude of roughly
180 km. The analog records obtained during these tests have
been digitalized by hand, and the resulting data are being
analyzed with a digital computer.

With the help of Mr. L. C. McGahan at the Pacific
Missile Range, a system is presently being developed that will
carry analog signals from the sensors, via telephone lines,
to a van in which they will be recorded on magnetic tape. The
analog signals on these magnetic tapes will then be auto-
matically digitalized by the Computing Facility at Point
Mugu and recorded on another magnetic tape in a format
compatible with the digital computer here on campus.

In the laboratory the new calibration chamber was employed to calibrate four modified Moore Variometers. The calibrations indicate that the threshold for detection of pressure variations with these instruments is below .01 microbar. In addition, the sensitivity, stability, and linearity of the instruments were found to be more than satisfactory. Construction of the second calibration chamber, which is to be used in testing acoustic detectors at simulated balloon altitudes and above, is well underway.

The laboratory is staffed at present by a half-time graduate student and a full-time technician. Efforts to find a material scientist to head the laboratory are in progress but have been unsuccessful up to now due to the dearth of qualified men in this field.

MAGNETIC FIELDS LABORATORY
P. J. Coleman, Jr.   Account No. 448623

Since completion in January, the magnetically shielded room has been in constant use testing instruments for OGO-E satellite and the ATS satellite. In addition, it has been used to test instruments for NASA, Ames Research Center, and for other investigators in the Institute.

ATMOSPHERIC TRITIUM
E. J. Flamm   Account No. 448618
R. E. Lingenfelter
A. Nir

The subject of natural tritium is reviewed from the inception of the search for this isotope in 1932 until the present. Three sources of natural tritium--production in the atmosphere by galactic cosmic rays, production by solar flare-accelerated particles, and accretion from the sun-- are considered. Reasonable agreement prevails among previous calculations of the cosmic ray production rate, the mean value being 0.30 tritons per cm^2-sec. A recalculation utilizing newer data is now in progress to determine the variation of production rate with altitude, latitude, and

solar activity. Production of tritium by interaction of solar flare-accelerated particles with the atmosphere is also being evaluated utilizing data on the flare-accelerated flux over the last solar cycle. Calculations of tritium production from material balance considerations have yielded rates ranging from 0.12 to 2 tritons per cm^2-sec. When the measured tritium concentrations of rain and ocean water on which these calculations are based have been corrected for synthetic tritium, the production rate from material balance is in agreement with the production rate by galactic cosmic rays.

LUNAR NEUTRON DOSE RATES

E. J. Flamm   Account No. 448620
R. E. Lingenfelter

Calculations of the natural radiation dose rate due to cosmic-ray produced neutrons at and near the lunar surface are being made in collaboration with W. N. Hess of Goddard Space Flight Center, Greenbelt, Maryland, and R. Wallace of Lawrence Radiation Laboratory, Berkeley. A range of possible lunar surface compositions is being considered.

PROMINENCE EMISSION LINE POLARIZATION

C. L. Hyder   Account No. 448627

Dr. Hyder was among the observers of the May 30 eclipse of the sun who followed the eclipse across the South Pacific. His special assignment was to analyze the linear polarization of light in the green line from the corona, using the polarimeter he designed which can detect one-twenty-thousandth of an inch wide in the corona's spectrum. Dr. Hyder's report follows:

The coronal eclipse polarimeter was successfully operated during the 30 May 1965 eclipse. The data have not been reduced, but there is clear evidence for polarization in the coronal green line. The light from the east limb was more polarized than the light from the west limb. This discrepancy will lead to information about coronal magnetic fields

and/or coronal collision processes.

The spicule, prominence, coronal arch, streamer model work was suspended during eclipse preparations.

Theoretical investigations of the validity of steady state cosmological models were begun. The methods of statistical equilibrium have been applied to different constituents of the universe to test these models. If it is found that the densities of all constituents are constant in space and time, then the steady state cosmologies will be found invalid. Specific studies of degenerate stars and stellar luminosity functions are being pursued.

The polarization work that was begun in 1963 is continuing. The filters purchased from NsG 237-62 funds will be used to study the polarization in the Orion Nebula and in the Crab Nebula. It may be possible to learn much about physical conditions in these nebulae from this observational study.

HIGH POWER PLASMA GENERATOR
C. A. Jensen   Account No. 448624
W. F. Libby
L. L. Wood

The UCLA one-half megawatt inductively coupled plasma generator project has completed all the preliminary test phases at less than rated power and is now undergoing final assembly in high power form.

The inductive coupling principle has been extensively tested to determine the characteristics of plasma systems with the various electrode geometries and oscillator circuit parameters. A general purpose, very efficient design has evolved which is being incorporated in the half-megawatt generator. The unique features of the design, notably abnormally high Q circuitry, screen grid power control, and modern rectifier design, have been shown to be desirable and important. The use of high Q circuitry offers much tighter coupling to the plasma, greater efficiencies, and much higher

plasma densities due to closure of current paths within the plasma. The screen grid power control and the nonsaturating transformer design, which it permitted, as well as the very high power rectifiers, will allow continuous operation in the 10-megawatt region for several seconds and will therefore greatly enhance the value of the instrument as a fundamental research tool.

Recent breakthroughs in the design of the coupling coil and gas injection system have completely eliminated the set of very serious problems of high voltage breakdown usually associated with power transfer at such levels, voltages, and plasma and photon densities.

The vacuum cavity and thermal insulator for the high power modification are presently being installed as well as the associated power equipment and electronic control circuitry. It is anticipated that installation and testing of this equipment will be complete within the month.

The work on the superconducting solenoids for the generator is proceeding as planned. These magnets will permit the generation of plasmas of very high densities and temperatures with this device.

After testing, the first application of the instrument will be in the area of crystal growing. Because the plasma generator is equipped with the necessary power in terms of temperature and photon fluxes of appropriate wavelengths and because the plasma cavity is contained in a high vacuum system, the first crystal which will be used is the diamond form of carbon. The equipment is suitable for cleaning the diamond surface by any desired method, keeping this surface clean and depositing fresh carbon in the diamond lattice form. It is anticipated that the limit to the size of the diamond crystal which can be grown will be determined only by the size of the generator and the appropriate cavity dimensions. In this device, this size will be of the order of ten centimeters.

The other primary application of the instrument, that
of determining oscillator strengths for astrophysically
important atomic and ionic states, will proceed as rapidly as
possible; this work has been progressing very satisfactorily
with smaller plasma generation units, but this more powerful
unit will permit work in previously marginally accessible
regimes, such as the far ultraviolet.

LASER ·

C. A. Jensen   Account No. 448624
W. F. Libby

The 584$\overset{o}{A}$ helium light source discussed in previous reports
is being adapted to function as a continuous gas laser. Be-
cause the operation of this device depends on the generation
of metastable helium atoms at high densities and because the
natural electric current limit of this device is several
orders of magnitude higher than those associated with typical
gas lasers, it is anticipated that the performance of any
such principles will be far superior to any such device in
existence up to the present time in both power output and
efficiency.

The high power light output variation with electric
current makes operation at high currents especially attractive.
For this reason, magnetic fields will be used to channel the
current flow and effectively enhance the current density. A
further application of magnetic fields will be in pulsed
operation to form very dense plasmas.

It appears possible that this instrument will permit
continuous operation at considerably shorter wavelengths than
has been hitherto possible, due to the variation of transition
probability with frequency and the natural wavelength limita-
tion this has imposed at present power levels as well as
the elimination of some optical problems which this design
appears to offer.

In conjunction with laser research, the plasma generator
discussed elsewhere in this report will be arranged in an

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optical cavity resonator. Because of the natural high power
levels of this instrument, as well as several of its other
unique features, it offers exciting possibilities as a laser.

ANALYSES OF CARBON COMPOUNDS IN CARBONACEOUS CHONDRITES
W. F. Libby   Account No. 448628

       The group met in Washington on April 19, 1965. Ab-
stracts follow of the papers presented at the meeting.

"High Resolution Mass Spectrograms of Segments of a Core
through the Murray Meteorite" - K. Biemann, John Hayes (MIT)

    A fragment of the Murray meteorite was manually cored
    along its major axis. The coring was done under care-
    fully controlled conditions in a dry box. Successive
    samples of dust from the approximately 1.5-inch coring
    were pulverized and placed in glass sample vials. Blanks
    were run before, after, and intermittently with the
    Murray samples. The findings were:
    1) Oxygen compounds are richer in the near-surface
       core samples.
    2) The hydrocarbon ion patterns are roughly the same in
       the successive samples.
    3) Comparisons of mass spectra of the volatiles from
       the Murray core segments and of the methanol eluates
       from silica gel columns of the benzene extracts of
       the Orgueil and Holbrook meteorites suggest that the
       numbers of different nitrogen-containing carbon
       compounds decrease in the series from Orgueil to
       Murray to Holbrook.

"The Nature of the Organic Matter in Carbonaceous Chondrites"
- H. C. Urey (UC-SD)
    The extensive data that have been gathered on the carbon
    compounds and "organized elements" in the Orgueil
    meteorite were reviewed. Seemingly, these data indicate
    that some meteorites contain either biological pre-
    cursors, which had chemically evolved to a highly

ordered state or biological remnants. Similarities between an acid resistant "organized element" and a microfossil from ancient terrestrial sediments were noted. The pros and cons of the question of the biologic origin of meteoritic carbonaceous materials were discussed, and a hypothesis that carbonaceous chondrites came from the moon was presented. This is to be the subject of Dr. Urey's paper at the COSPAR meeting in Argentina.

"Nature of the Hexane Extract of Orgueil" - B. Nagy (UC-SD)

Found the hydrocarbons extractable from Orgueil to be similar to those extracted by Oro from the Gunflint shale.

"Problems Associated with the Analyses of Amino Acids in Carbonaceous Chondrites" - P. B. Hamilton (DuPont Institute)

Modern analytical techniques are so sensitive that a complex array of amino acids may be detected in a fingerprint. Simple chromatographic analyses do not provide reliable identifications of amino acids. Equivalent chromatograms may be obtained for two entirely different mixtures of amino acid. Minerals can alter or destroy certain amino acids. An effort is being made to analyze the amino acids that are obtained by severe hydrolizing methods after the easily extractable or hydrolyzable acids are removed from meteorites, but detailed investigation of analytical methods and results is required before the significance of any determination of amino acids in meteorites can be ascertained.

"Danger of Biological Contaminants" - P. H. Abelson (Carnegie Institution, Geophysical Laboratory)

Mold is commonly found on geochemical samples. Such biological contaminants may lead to errors in paleobiological samples.

"Alkanes in Ancient Sediments and Chondrites" - W. G. Meinschein (Esso Research and Engineering)

Successive benzene extracts of intact, crushed and HF treated rocks from the 2.7 billion year old Soudan rocks contain alkanes that probably include pristance and phytane. Compositional differences in the alkanes from the successive extracts indicate that the alkanes released by HF were probably the major source of the alkanes obtained from the whole and crushed rocks and that the latter alkanes were chromatographically fractionated within the rocks. Alkanes have been isolated from six ordinary chondrites by a variety of extraction methods. The alkanes from five of the chondrites are compositionally analogous. The sixth chondrite was obviously contaminated with paraffin-wax. Analyses of successive extracts of the Waconda and Holbrook chondrites indicate that the alkanes are uniformly distributed in the interiors of these meteorites. The chondritic alkanes contain pristane and phytane and resemble alkanes in some Cambrian and Precambrian terrestrial sediments.

"Isoprenoid-Type Hydrocarbons in the Nonesuch Shale and Soudan Formation" - A. L. Burlingame and T. Belsky (UC-B)

Pristane and phytaine have been identified in alkanes from the one billion year old Nonesuch shale and the 2.7 billion year old Soudan formation. In addition, the C_{18} and C_{21} homologs of pristane and phytane were found in extracts of the Soudan rocks. These alkanes are structurally related to the phytol moiety in the chlorophyll molecule, and they are probably of biological origin. n-Paraffins in the C_{15} to C_{32} range, also, were identified in the extracts of these ancient rocks.

"Hydrocarbons in Carbonaceous Chondrites and the Gunflint Chert" - J. Oro (University of Houston)

Analyses have been obtained of the alkanes from various carbonaceous chondrites, different fragments of the Orgueil meteorite, and the Gunflint chert.

The findings were:

1) The compositions of alkanes from Type I, II, and III carbonaceous chondrites vary.

2) Distributional variations have been observed in alkanes from different fragments of the Orgueil meteorite, but it appears that it is possible to recognize these alkanes as being from this carbonaceous chondrite.

3) Some fragments of Orgueil contain approximately 8 times the concentrations of alkanes that are present in other fragments of this meteorite.

4) All the meteoritic alkanes seem to contain pristane and phytane.

5) Odd carbon-numbered n-paraffins are more abundant than even carbon-numbered n-paraffins in some but not all fragments of the Orgueil meteorite.

6) Alkanes from the Orgueil meteorite are similar to those from the Gunflint chert. This chert is approximately 2 billion years old. It comes from northern Michigan, and it contains well-preserved microfossils.

"Pyrolysis Products from Carbonaceous Chondrites" - T. C. Hoering (Carnegie Institution, Geophysical Laboratory)

Heated to 350°C and analyzed gas chromatographically. Although transformations occur during the pyrolysis (as shown by isotopic tracers), the pattern is changed little by total demineralization (with HF) before pyrolysis and thus would seem to have some significance. This is a good way of handling the main insoluble organic in a small sample (few mgms). Found Murray, El Rais, and Orgueil all to give patterns very different from any terrestrial rock. (Note that this disagrees with the hydrocarbons by extraction.)

"Fatty Acids from Chromic Acid Oxidation of Kerogen" - T. C. Hoering

Found abundant yield of C_{16} to C_{24} fatty acids (and

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higher) with strong even/odd preference in Fig Tree
Shale from South Africa which is about 3.2 AE old.
It is planned to try this on Murray and other car-
bonaceous chondrites.

Attending were:

P. H. Abelson, Geophysical Laboratory, Carnegie Inst.
T. Belsky, UC-Berkeley
Klaus Biemann, MIT
I. A. Breger, USGS
A. L. Burlingame, UC-Berkeley
Kurt Fredricksson, Smithsonian Institution
P. B. Hamilton, DuPont Institute
John Hayes, MIT
T. C. Hoering, Geophysical Lab., Carnegie Institution
I. R. Kaplan, UC-Los Angeles
W. F. Libby, UC-Los Angeles
Gregg Mamikunian, NASA-JPL
Brian Mason, American Museum of Natural History
Warren Meinshein, Esso Research and Engineering
Bartholomew Nagy, UC-San Diego
John Oro, University of Houston
J. P. T. Pearman, National Academy of Sciences
Cyril Ponnamperuma, NASA-Ames Research Center
Freeman Quimby, NASA-Biological Space Programs
R. Richardson, Esso Research and Engineering
David Stevenson, Shell Development
H. C. Urey, UC-San Diego
H. B. Wiik, Finland (Arizona State College)

Future plans and conclusions:

Another informal meeting will be held in September at
the time of the next AGU meeting.

NEUTRON-ACTIVATION STUDIES OF METEORITES AND OF NATURAL
GAMMA- OR POSITRON-EMITTING NUCLIDES

J. T. Wasson   Account No. 448651
J. Kimberlin

A paper entitled "Determination of Neutron Activation
of Gallium and Germanium in Iron Meteorites" has been accepted
for publication in Radio-chimika Acta. An abstract of the
paper follows:

Abstract

A procedure is given for the simultaneous determination
by neutron activation of gallium and germanium in iron meteo-
rites or other similar materials. Germanium is separated

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from interfering activities by solvent extraction from 8
N HCl into carbon tetrachloride followed by distillation as
$GeCl_4$. It can be separated fast enough to allow counting of
the 82-min Ge^{75}. The chemical yield is determined colorimet-
rically using phenylfluorone. Gallium is separated by repeated
solvent extractions into isopropyl ether. After counting,
the chemical yield is determined by flame photometry. About
12 man-hours are necessary to process six to eight samples,
not including the time necessary to reduce the counting
data. The detection limits for a thermal neutron flux of
10^{12} cm^2 sec^{-1} are about 0.02 ppm germanium and 0.0001 ppm
gallium.

STELLAR RADIOACTIVITY

L. L. Wood   Account No. 448624
W. F. Libby

Analysis and interpretation of data from the first
Orbiting Solar Observatory, generously provided by Dr. John
Lindsay's Solar Physics Group of Goddard Space Flight Center
and reported previously, have proved quite fruitful. Un-
equivocal evidence for the existence of hyperthermal processes
in the atmosphere of the nominally quiet sun has been derived
from the analysis of data from the gamma ray and EUV spec-
trometers on OSO-1; these processes are almost certain to
involve nuclear reactions and synthesis of radioisotopes on
the solar surface to a significant extent. These processes
probably occur principally in disturbed portions of the
solar disc, although the evidence for this is at the moment
mainly statistical.

These processes have been interpreted in terms of energy
sources involving turbulently driven magnetic fields which
exhibit high frequency plasma instabilities; this mechanism
arises rather naturally and directly from first principles,
and it is considered likely that mechanisms of this general
type are responsible for a wide variety of previous under-
interpreted solar phenomena.

These high energy solar phenomena in turn are linked to

a large set of geophysical processes; the short-time development and long-term evolution of the terrestrial atmosphere in particular and planetary atmospheres in general are among the areas being considered in the light of this new knowledge.

The mechanisms and processes invoked to explain both previously extant data, as well as those from OSO-1, are of quite general applicability and can apparently be readily linked to all late-type stars, irrespective of luminosity or spectral class, on the basis of previously published data. It seems that most stars will necessarily sustain processes similar to those occurring on the sun and that some star-wide high energy events, which are occasionally observed, are quite natural extensions of the mechanisms which are apparently involved in more normal stars.

The significance of this present work to the energy deficit in current models of the solar wind, as well as methods for improving our operational knowledge of solar meteorology and the associated hazard functions for the Manned Space Flight Program will also be discussed in papers being prepared for publication.

BIOLOGICAL SCIENCES

PROGRAM TO ASSESS BASIC PHENOMENA UNDERLYING BEHAVIORAL
ASPECTS OF COMPLEX LIVING SYSTEMS IN SPACE

J. D. French   Account No. 448604
W. R. Adey

Plans are well in hand for development of the full scope
of these programs when occupancy becomes possible in the
Space Science Building, anticipated for the late fall of this
year.

In particular, programs are being initiated in fun-
damental physiology and cytology, as these appear particularly
relevant to problems known to arise, or likely to occur,
in the space environment.

It is planned to install an electron microscopy facility,
which will have as its basic aim an evaluation of changes in
fluid distribution in tissue compartments, particularly in
the brain under conditions of altered gravity. These
studies will be correlated with much work already done with
assessment of such factors by the use of impedance measuring
techniques and other methods that have indicated subtle but
highly significant changes in fluid distribution between
these compartments in normal and pathological conditions. It
is intended that this program will include aspects of cyto-
chemistry and biochemistry, particularly in the area of
steroid hormones and the effects of altered environmental
factors in their release from the adrenal glands.

Mention may be made here of work already supported in
this way. The programs of Dr. Cockett at the Harbor General
Hospital have been involved with renal functions in the
space environment and with ways to simulate the effects of
weightlessness on renal function. Dr. Mandell is engaged
in studies that have to do with the effect of steroid sub-
stances on intermediate metabolism in a number of body
systems. This represents a pioneering effort beyond the
current generation of experiments in steroid metabolism,

which have concerned themselves primarily with the control
of release of the steroids, rather than with their effect
in target organs. The studies of Dr. Mandell are likely to
shed extremely valuable light on later phases of steroid
control mechanisms. Dr. E. Decima has continued work
initiated by the late J. D. Green relating to the effects
of calcium metabolism in spinal nerve cells. This work
bears directly on the problems of calcium metabolism as it
may be modified in the space environment. Also in the area
of control of motor functions, Dr. Jennifer Buchwald has
investigated the control of the strength of contraction
through the muscle spindle apparatus. Knowledge in this
area is vitally important to an understanding of the ways
in which the mammalian motor mechanism must adapt to weight-
lessness, particularly in the retention and reconditioning
of skilled motor acts.

Changes in Neuronal Unit and Slow Wave Activity During Behavioral Conditioning

J. S. Buchwald

Basic to any learning problems encountered in space
is an understanding of brain function during learning in a
"normal" environment. In a preliminary report, it was shown
that action potentials from multiple-units could be clearly
recorded in unrestrained animals through chronically im-
planted macroelectrodes. During behavioral conditioning
procedures, the development of conditioned patterns of
multiple-unit activity was found to differ markedly from one
anatomical structure to another and from one stage in the
training procedure to another. In contrast, concomitant
recordings of EEG slow waves from the same electrodes often
showed little or no corresponding change. In an attempt
to determine the value of this recording technique as a
helpful adjunct to present methods, studies have been
initiated to examine multiple-unit activity patterns in
some of the major systems of the brain during a behavioral
conditioning procedure. The specific purposes of these

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recordings are directed toward determining (1) where consistent conditioned changes in neuronal activity appear prior to the overt conditioned response (CR), concurrently with the overt CR, and where little or no change in activity occurs; (2) whether the conditioned changes are represented by an increase or decrease in neuronal discharge; and (3) whether a sequential development of conditioned unit responses can be traced from one system or from one level of sensory integration to other structures subsequently activated. As responses with the systems most basic to conditioned learning are still not clearly defined during the development of a behavioral conditioned response, the primary projection pathway of the CS and the primary projection pathway of the US, as well as the nonspecific, diffusely projecting reticular system, have been the focus of this initial study. Prior to conditioning a hindleg flexion response, electrodes were implanted at stations in the direct CS projection pathway, the direct US projection pathway and the diffuse reticular system in each of 9 chronic cats. By the use of appropriate filters, EEG and multiple-unit activity were simultaneously recorded from each electrode during habituation to the tonal CS, training in which the CS was paired with shock to the hindpaw, extinction and subsequent retraining. Terminally all electrode placements were histologically verified. In the CS projection pathway recordings from the brachium of the inferior colliculus, medial geniculate body and post-ectosylvian cortex indicated that unit activity patterns shifted from habituation to dishabituation after US reinforcement, and with successive trials these responses progressively increased. Similarly, early in training, responses appeared in the reticular formation at both mesencephalic and thalamic levels. In the US projection pathway recordings from the medial lemniscus, nucleus ventralis posteriolateralis and post-cruciate cortex indicated little or no unit response to the CS prior to the appearance of the overt response. Thus, potentials recorded from a population of neurons may show

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specific response patterns during behavioral conditioning directly related to activity at the recording site. The present data suggest that activation of the CS and reticular systems are primary events in conditioning. While these marked unit responses of either accelerated or inhibited discharge to the CS developed, little or no concomitant change was evidenced in the slow wave EEG recorded from the same sites. Such results indicate that local changes in multiple-unit activity may occur quite independently of the EEG and that these unit recordings reflect changes during learning much more sensitively than the EEG. These findings may have a direct relationship to adaptive motor phenomena in the early period of exposure to prolonged weightlessness.

Effects of Calcium Metabolism in Spinal Nerve Cells

E. E. Decima

A. Role of calcium ions on synaptic transmission in the mammalian central nervous system.

The monosynaptic reflex (M.R.) in the spinal cord of parathyroidectomized cats was studied. The results show that:

1. In severe hypocalcemic tetany (hypoparathyroid tetany) the M.R. is absent, even in the period of potentiation normally seen after a high-frequency stimulation, i.e., post-tetanic potentiation is also absent. Spontaneous seizure activity of the spinal motoneurons may be observed in these animals also.

2. After calcium ions were given intravenously, the M.R. could be obtained. However, there was a gap of 2-3 hours between first normal calcemia and the appearance of M.R. This was probably due to a blood-barrier phenomenon.

3. The results reported herein are additional proof of the chemical nature of the synapsis between IA fibers and the spinal cord motoneuron because, as in the chemical transmitting synapsis, calcium ions seem essential for synaptic transmission to occur.

B. Studies of presynaptic mechanisms in post-tetanic potentiation (PTP).

In previous studies a slowing of conduction velocity (c.v.) of IA fibers during PTP had been observed. In the experiments to be reported here, this change in conduction velocity was studied at the periphery (with "gross" electrodes) and at the central level (with glass micropipettes). The results show:

1. Hyperpolarization of IA fibers was not observed regularly. In the cases in which it occurred, it did not follow the time course of PTP.

2. The shape and duration of the spikes were altered only immediately after the end of the tetanus, the spike being smaller and the rate of repolarization a little slower than the controls. However, these effects lasted only a few seconds and were not observed throughout the period in which c.v. was changed.

The possibility that some small changes could be detected by intrafiber stimulation (through the recording micro-electrode) is being tested at the present; the rate of de-polarization of the local response and the threshold depolarization are being especially analyzed.

Renal Functions in the Space Environment
A. T. K. Cockett

Drs. Cockett and Nakamura have extended their work in decompression using tagged albumin particles (I^{131}) injected into the circulatory system to radiographically map the lung field. Their preliminary observations have shown marked blockage of the pulmonary arterial circulation following a precipitous decompression. Studies in the use of plasma volume replacement with and without hypothermia have resulted in very successful recovery from decompression sickness without the usual recompression procedures. This finding will become of great importance if gaseous environments with atmospheric components are used in spacecraft since the habitable environment will be at a greater pressure than the external environment.

The work relating to the formation of urinary calculi has shown significantly smaller formations in experimental animals kept in isolation for extended periods against normally exposed controls. Similarly, exposure to low dosage whole body irradiation for eight weeks resulted in significantly smaller bladder calculi than found in a control group. The formations, however, appear to be critically dose-related, approximately 300 vβ at a rate of one Roentgen per day.

Renal function has been investigated in its relationship to partial obstruction of the ureter. Renogram examinations have proved to be sensitive indicators of obstructive urinary flow patterns.

Study of antibacterials in the lymphatic system of the kidneys has demonstrated that renal lymph is a better indicator of certain antibacterials in the tissues than are blood levels. The lymphatics probably play an important role in renin-angiotensin transport to the adrenal glands and the systemic circulation.

The third study in renal physiology has been concerned with the production of graded renal blood supply insufficiency employing an electromagnetic flowmeter. Oxygen saturation and oxygen tension in the renal vein are significantly reduced following graded renal artery compression. Similarly, lactic acid levels are elevated, and the pH is reduced (more acidic) in the renal vein draining the ischemic kidney.

Studies of this nature provide a means for more directly assessing kidney function and may be applied to various situations where environmental influence may be overriding.

Effects of Steroid Substances on Intermediate Metabolism
A. J. Mandell

We are involved in a two-phase program related to elucidating neuroendocrine and metabolic correlates of central nervous states in man. These approaches, we feel, will add correlative and meaningful data to the electrophysiological studies of the central nervous system in sleep and stress states in man

already going on in the Space Biology Laboratory.

The first phase of our program involves the correlation of three neuroendocrine parameters as well as some metabolic and renal function changes associated with different EEG stages of sleep; especially the rapid eye movement stage. Using urinary catheter adapted, hospitalized, urology patients with normal renal function studies, we are correlating different EEG stages of all-night sleep records with reflections of ADH, ACTH, and catechol amine release in the urine, which is collected continuously in a volume-regulated fraction collector. We have done several nights now on four subjects, and rather consistent results are beginning to appear: it appears that there is a marked drop in urinary volume per minute during the onset and early phase of rapid eye movement periods; it appears that there is a marked release of ACTH during the REM period as reflected by increases in urinary 17-hydroxy-corticoids; and we are currently checking for changes in catechol amine excretion (via the major metabolite, VMA) and are doing osmolarities and creatinine to see if the urine volume changes are secondary to changes in GRF (which is unlikely) or due to the release of an ADH-like substance. We are, in addition, studying protein mobilization during REM periods. Postulating that there may be a nutritional function to the periodic REM state (fatty acids go up, corticoids which lead to gluconeogenesis go up, perhaps glycogen mobilizing catechols go up, etc.), we wondered if the periodic corticoid rise would be of sufficient magnitude to mobilize protein. We therefore gave small amounts of C^{14} tryptophan to subjects several hours in advance of going to sleep so the plasma level would stabilize, and using venous catheters, serial blood samples were collected and radioactivity determined during the night and correlated to REM periods. If there was amino acid mobilization associated with the REM phenomenon, we would see predictable increases in plasma radioactivity at some interval (probably 20 to 40 minutes) following the REM epoch. These data are currently being analyzed. In general, the knowledge of the correlates of these sleep EEG states

will add information to EEG studies, as for example might be monitored in space.

The second phase of our program is the systematic study of adrenal glucocorticoid secretion during psychological stresses and the associated changes in amino acid enzyme activity as reflected by differential turnover of a number of metabolites of a single amino acid (tryptophan), using small amounts of isotopic tryptophan in man. Our search is for more subtle metabolic indicators of psychological stresses in man. We have recently obtained some evidence that certain pathways in tryptophan metabolism are differentially increased in rate over control pathways in response to small amounts of ACTH (and accompanying rises in plasma 17-hydroxycorticoid that are similar to those seen in psychological upset). We are currently examining both 17-hydroxycorticoid levels and tryptophan metabolites during the cyclic psychological decompensation of patients with periodic psychoses. We will begin to work with more subtle behavioral stressors in association with EEG studies of stress in man going on in the Space Biology Laboratory as soon as the parameters of our metabolic-dependent-variable have been worked out.

THE EFFECT OF ROCKET EXHAUSTS CONTAINING CERTAIN ELEMENTS
ON ROCKY INTERTIDAL MARINE COMMUNITIES ON SAN NICHOLAS ISLAND
R. A. Boolootian   Account No. 448674
R. I. Caplan

In a previous report (July 1965) preliminary results obtained during a year of field study (June 1964 to June 1965) of the marine flora and fauna at San Nicholas Island were given. In that report the number of species, 31 animal and 44 plant, which were included in the zonation study was indicated. The dominant species in each study area (Area 1 and Area 2) was indicated without specifically defining the zones in which they occurred. It was further stated that preliminary analysis of data collected during the fall (August 1 to September 18, 1964), the winter (December 12

to 23, 1964), the spring (March 21 to 25, 1965), and the
summer (June 12 to 15, 1965) periods indicated the presence
of seasonal trends in population density fluctuations. The
zonation pattern as well as the seasonal trends is discussed
in this report.

The pattern of zonation of flora and fauna in both study
areas is divided into four basic belts or zones. Each belt
is characterized by several dominant animal and plant species
whose maximum abundance occurs within the belt. These belts
are arranged serially along the study transects in each area;
the range of each is given in feet above the zero tidal level,
Mean Low Low Water. Since the ranges of these belts as well
as the species which characterize the belts are similar for each
area of study, the zonation patterns are concurrently discussed.
The uppermost belt (+11.0' to +7.5') contains a barnacle,
Chthamalus fissus, a snail, Littorina planaxis, and the algae,
Ulva (Area 1) or Endocladia muricata (Area 2). Between this
zone and the next, a transitional species of algae, Cladophora
trichotoma, exists. In the next zone (+7.5' to +4.5'), the
dominant species are a limpet, Acmaea digitalis, a snail,
Littorina scutulata and the encrusting algae, Ralfsia pacifica.
The transitional species between this belt and the next is the
barnacle Tetracilta squamosa rubescens. The third belt
(+4.5' to +3.0') is dominated by a mussel, Mytilus californianus,
two species of limpets, Lottia gigantea and Acmaea scabra, and
the algae Endocladia muricata. In Area 2, however, Mytilus
californianus is replaced by the anemone, Anthopleura
elegantissima, while Endocladia muricata is replaced by Plo-
camium coccineumn. The fourth and lowest zone (+3.0' to
0.0') contains two species of coralline algae, Corallina
vancouveriensis and Lithothanmnium, and the chiton
Nuttalina californica (Area 1 only). Similarities in the
patterns of zonation between the two study areas enable the
utilization of Area 2 as a control for further study of
Area 1.

After completion of the zonation study, several regions

in each area of study were selected in order to determine the magnitude of seasonal variations in population densities of the major species in each zone. These seasonal trends were determined by analyzing the seasonal collection data with the Wilcoxon Sign Rank Test. This analysis revealed that there was a significant decrease in the number of adults during the period from fall 1964 to summer 1965. This trend was most marked during the period between fall and winter 1964 in populations of <u>Chthamalus fissus</u>, <u>Acmaea scabra</u>, <u>Mytilus californianus</u>, and <u>Littorina scutulata</u>. This decrease in abundance was maintained from winter 1964 to summer 1965 in populations of <u>Mytilus californianus</u> and <u>Littorina sucutlata</u> only. During the period of study, three species contained juvenile individuals that had various effects on the adult population trends mentioned. These juveniles played a minor role in populations of <u>Tetraclita squamosa rubescens</u> and <u>Chthamalus fissus</u>. However, in populations of <u>Littorina planaxis</u>, the juvenile group was responsible for a general increase in the abundance of this species during the spring and summer periods of study (March to June, 1965).

The magnitude of these seasonal trends is reflected by the patterns of adult and juvenile mortality during the period of study. Four types of adult populations were present with each showing a different degree of mortality. The first type is characterized by <u>Chthamalus fissus</u> in which the annual mortality was very high, e.g., 60%. <u>Mytilus californianus</u> had the next highest mortality during the study period, e.g., 40%. The mortality in populations of <u>Acmaea digitalis</u> was low during the period of study as compared to <u>Chthamalus fissus</u> and <u>Mytilus californianus</u>, e.g., 40$. Adult populations of <u>Anthopleura elegantissima</u> showed minor fluctuations in abundance, the annual mortality being only 10%. In three species which contained juvenile individuals, mortality was also studied. The highest juvenile mortality was noted in populations of <u>Tetraclita squamosa rubescens</u> in which 80% of the individuals died within a six-month period (December

24, 1964, to June 15, 1965). The mortality for populations
of <u>Littorina planaxis</u> was half that for <u>Tetraclita</u> during
the same time period; an increase in juveniles was noted
for <u>L. planaxis</u> in some of the zones studied. The most stable
juvenile population occurred in the barnacle <u>Chthamalus fissus</u>,
as only a 10% mortality was recorded during the period of
study.

The first year of study has provided valuable information
concerning biogeographic position of San Nicholas Island.
Comparisons of the flora and fauna on this island and other
Channel Islands demonstrate that this association of species
belongs to the northern boreal province whose southern limit
is Point Conception. Another year of field work is both
necessary and desirable in order to quantify this finding as
well as to determine the magnitude of changes in zonation
patterns and seasonal trends. Further investigation will
serve to reinforce the data already gathered after which
time the rocket tests may resume.

PATTERN RECOGNITION OF SENSORY SIGNALS IN ANIMALS
T. H. Bullock   Account No. 448675

This grant was for the purpose of equipping a new
laboratory in the new Marine Neurobiology Facility of the
Brain Research Institute located on the third floor of the
new Physiology Research Building on the UC-SD campus. This
building is nearly completed as of September 15, 1965, but still
lacks sinks, laboratory benches, and the like. We have
therefore been unable to start this research. However,
most of the items of equipment to be purchased under this
grant have been ordered and delivered. One or two items
have not been ordered, particularly a micromanipulator.
The research will commence the day that the laboratory is
capable of being used, since Dr. Bullock himself is on
sabbatical leave this year and is in residence in La Jolla,
where he has this equipment ready to be installed and has
borrowed micromanipulators until the new ones are received.

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This equipment will assure that the newly constructed Marine Neurobiology Facility of the Brain Research Institute will begin operation on a full scale of experimental research immediately as it is ready for occupancy, at least with respect to this one laboratory. The other laboratories will similarly be put to use immediately by corresponding support from other sources. The productive employment, therefore, of this new facility will be maximal from the outset, and it is our hope and expectation that significant scientific results and discoveries will ensue at a very creditable pace in view of the highly specialized and unusual advantages of the site and its ancillary facilities and of the high level of scientific personnel that it has been possible to recruit and put into these laboratories; all of them already in residence and literally waiting with equipment in hand to move into the space.

HIGH ENERGY ELECTRODES IN NON-AQUEOUS ELECTROLYTIC
SOLUTIONS
D. N. Bennion   Account No. 448632

Batteries which exhibit high energy per unit weight ratios
are a necessity in space exploration. This research is di-
rected toward gaining necessary fundamental information re-
quired to realize improved electrochemical power systems for
space application. Aqueous electrolyte systems have been ex-
tensively studied; however, the potentialities of non-aqueous
systems have only recently begun to be investigated. Many high
energy electrodes corrode rapidly in aqueous systems as well as
showing other undesirable kinetic behavior which is often not
present in non-aqueous environments.

It is the purpose of this research to investigate promising
combinations of electrolytic solvents, electrolytes, and electrode
materials. Emphasis is being placed on high energy per unit
weight combinations which offer possibilities of fabrication
into practical cells.

The reduction of meta dinitro benzene in a lithium nitrate
solution is being investigated, using liquid ammonia as solvent.
The reaction will then be studied, using DMSO as the solvent.
Determination of the reaction mechanism and rate determining
step are an immediate goal. It appears likely that the rate
controlling step is the mass transport of dinitro benzene molecules
from the bulk dinitro benzene phase to the surface of the carbon
where the electrochemical reduction can take place. An experi-
mental technique for determining this is now in the advanced
developmental stage.

SURFACE TEMPERATURE MEASUREMENT ON SUBLIMATING SURFACES
A. F. Charwat   Account No. 448641

To study the effects of sublimation of relatively low
temperature materials, one turns to the utilization of the
fluorescence of certain inorganic materials.

This class of luminescent materials, known as thermographic phosphors, emit in the visible spectrum when excited by ultraviolet radiation. This phenomenon is basically the result of electrons which, after being raised to an excited state by the ultraviolet radiation, emit energy in the form of fluorescence as they return to the ground state. Both the intensity and the spectral distribution of the fluorescence depend on temperature. Other factors such as the intensity of the ultraviolet excitation source also affect the intensity of the fluorescence. This method, developed by Paul Thureau in France for use in studying high speed convective heat transfer, is being adapted for the study of low temperature sublimation of materials such as camphor and napthalene.

Various types of phosphors are being investigated. The phosphor material in powder form will be mixed with the camphor or napthalene prior to fabrication of the model by compression sintering. This will allow for continuous measurements during testing. The most promising phosphors will be calibrated using an oven to heat the models to specified temperature levels and taking the measurements in the oven.

This surface temperature measurement apparatus will then be used to determine the surface temperature of camphor and napthalene during sublimation as a final checkout test.

MATERIAL SHAPING BY ELECTROLYSIS AT HIGH CURRENT DENSITIES
R. R. Cole   Account No. 448647

Actual work on the project was scheduled to start October 1, 1964. However, the borrowed equipment was not shipped as originally promised, and there was a further delay while waiting for the ground to dry out sufficiently for the heavier pieces to be moved into the building. Work (and charges against the budget) was therefore not started until January 1965.

The first goal which was set for the project was to identify the main process variables which control the dissolution of the anode. For this purpose an electrolytic cell was designed and built. This cell employs a simple electrode

geometry and enables the high current density electrolytic reaction to be observed and photographed for the first time.

Observations of the flow in the gap reveals that a considerable region next to the anode is occupied by a vapor phase. This region increases in thickness from the leading edge. It was found that the thickness of the two-phase region strongly depends on the electrolyte velocity and the current density. The fact that the mass transfer of ions through the gap is affected by the two-phase region can be seen from the decrease in the gap distance with the increase of the two-phase region. Plots of current vs. voltage and flow rate also indicate that the two-phase region plays an important part in the mass transfer of ions through the gap. Further correlations between the current density, electrolyte flow rate and electrode gap and the length of the single-phase region and the thickness of the two-phase region are now being made. Results of these correlations are encouraging, but more data are required.

Plans for Future Work

Work during the next year will continue to be directed toward gaining a better understanding of the fundamental mechanisms of the process.

With the newly developed electrolytic cell and technique for actually observing and photographing conditions in the electrode gap during passage of current, it should be possible to derive and experimentally verify a relation to express the change in conductivity of the electrolyte as it passes through the electrode gap. Since equations for electronic computer application are already available for computing the cathode contour for a desired anode contour, assuming an unchanging conductivity of the electrolyte, such a relationship would permit these equations to be modified with considerable improvement in their industrial application.

In past work anomalous results for current efficiency have been obtained by us and by other investigators. It is planned to investigate the current efficiency with the help of the new

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cell and to collect and analyze the products of the reaction. By this means it should be possible to obtain a better understanding of the chemistry involved in the process.

TWO ASPECTS OF THE INFLUENCE OF DISSOLVED HYDROGEN ON THE BEHAVIOR OF IRON AND STEEL

A. E. Flanigan   Account No. 448649

Many problems stem from the interaction of iron with hydrogen. As is well known, the presence of dissolved hydrogen can exert undesirable effects on mechanical behavior. In some applications (as in some pressure vessels), the diffusivity of hydrogen is of interest. In certain processes (as in the cooling which follows high-temperature welding), the presence of hydrogen may even influence the phase transformations which tend to occur.

The present work concerns experimental investigations in the following areas:

1. The influence of hydrogen in the strain aging of iron.
2. The influence of hydrogen on the bainite transformation in steel.

Hydrogen and the Strain Aging of Iron

It has long been known that dissolved carbon and nitrogen can produce strain aging in iron. Recently, it has appeared that dissolved hydrogen may also contribute to strain aging.

The NASA support has assisted the extension of an investigation of hydrogen-induced strain aging. Prior to the support, James Kaae, then a Ph.D. candidate at UCLA, had obtained some interesting data which indicated that hydrogen, introduced by electrochemical means, could contribute to strain aging in iron. The extension involved strain-aging studies after the introduction of hydrogen thermally, i.e., by heating in a hydrogen atmosphere. This investigation has been completed, and a complete description is in the

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Ph.D. dissertation of Mr. Kaae.

Dissolved Hydrogen and the Bainite Transformation

In a recent M.S. thesis by Norman Ahlquist it was shown that the presence of dissolved hydrogen can produce an acceleration of the bainite transformation in steel. A thesis project of another graduate student, John Li, has been initiated to investigate this new and interesting discovery.

It has been shown, by means of experimental results, that the effect of hydrogen on the rate of the bainite transformation is due to the direct influence of dissolved hydrogen. The effect is not caused by decarburization produced during the introduction of hydrogen.

Other experiments have been carried out to determine the effect of hydrogen on the rates of nucleation and growth. The results are being evaluated and analyzed.

PLASMA RESONANCE IN SOLIDS AND MICROWAVE APPLICATIONS
W. D. Hershberger   Account No. 448645

The purpose here is to determine experimentally whether plasma resonances may be observed in optically-excited semiconductors and to study their possible uses in optical modulation and demodulation.

Disks of low resistivity In Sb were ordered and received for the work. A study of the literature on uses made in the past of semiconductors for mixing optical and microwave frequencies is currently underway.

A research proposal entitled "Research on Optical Modulation and Demodulation using Plasma Resonance in Solids" was submitted to NASA in April 1965. Two graduate students will be available in the fall of 1965 to work intensively on the project.

QUANTIZATION ERRORS IN HYBRID COMPUTATIONS

W. J. Karplus   Account No. 448630
J. Vidal
R. Wood

Quantization is the process of converting a continuous analog signal to a digital code work of finite length. Since the output of a quantizer can take on only a finite number of values, while the input is continuous, errors inevitably result. The efficient interconnection of analog and digital devices demands that a given error level be maintained with as short a digital word as possible. Current research is directed toward extending the theory of optimum quantization for both serially correlated signals and for independent signals. In particular, the effect upon the optimization process of buffering and of encoding is being considered. It has been shown that if buffering and encoding are performed, the conventional optimization procedures based on fixing the number of levels in the quantizer do not apply, and, in fact, yield a poorer result than simple equi-interval quantizing. Equations for the optimization of the quantization process in the presence of buffering have been derived, and some numerical solutions computed. Then preliminary investigations indicate that for Gaussian signals equi-interval quantizing yields results very close to the optimum.

In addition to this new effort, research is continuing in the utilization of sensitivity coefficients for the control and correction of quantization errors. Some results of the research were published in the following paper: J. Vidal and W. J. Karplus, "Characterization and Compensation of Quantization Errors," Institute of Electrical and Electronic Engineers, International Convention, <u>Convention Record</u>, Part III, March 1965, pp.236-241.

COUPLED WAVEGUIDE ANTENNAS

E. H. Kopp   Account No. 448636

The purpose of this research is to study a new type of microwave antenna. This antenna, employing two coupled

waveguides, is attractive for application in high-speed vehicles such as supersonic aircraft and space satellites because of its flat radiating surface. The new antenna offers promise of both easier fabrication and more versatile application than existing types. Further development should permit this design to be considered for microwave radar or communication systems.

During the period from March 10 (award of the grant) to June 30 (during which time work was on a 1/5-time basis), work on the project was pursued along three lines:

a) Dissemination of the results of the Ph.D. thesis of E. H. Kopp.

b) Submission of a proposal for more permanent support of the research.

c) Investigation of the properties of square waveguide, in order to use this guide as the basic configuration for future coupled waveguide antennas.

The dissertation was revised, submitted, and accepted for presentation at the 1965 International Symposium on Antennas and Propagation sponsored by the Institute of Electrical and Electronics Engineers, held in Washington, D.C., August 20$_r$ September 1, 1965. A summary will appear in the Symposium Digest and will carry the note, "The presentation of this paper is supported by NASA under Grant NsG 237-62."

Further revision is continuing, and the dissertation will be submitted for journal publication in the near future.

A proposal for support of the research for the 1965-66 academic year has been written and was submitted to the Air Force Cambridge Research Laboratory on June 1. AFCRL is presently considering this proposal.

Square waveguide is particularly attractive for the coupled waveguide antenna because two waveguide modes may be propagated in a single structure (the TE_{10} and TE_{01} modes of waveguide theory). In order to use this guide in antenna design, it is necessary to have numerical data on a coupling

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configuration and a radiative configuration in this waveguide.

A "jig" has been designed and constructed for obtaining these data for "wedge" coupling and for longitudinal slot radiators. Preliminary measurements have shown that a minor revision of the jig was necessary, and this has been completed. However, the revised jig has not yet been tested. If--as expected--the jig now performs satisfactorily, the necessary data should be easily obtained. These data will be included in the next report.

ULTIMATE STRENGTH AND STRESS FIELD OF PLATES AND SHELLS UNDER LATERAL PRESSURE AND EDGE COMPRESSION

T. H. Lin   Account No. 448633
J. E. Taylor

The main object of this research is to develop a unified method to analyze structures to their ultimate strength. By means of the analogy between inelastic strain gradients and body forces, elastic solutions can be used to get the corresponding inelastic solutions. In our previous work, the following problems have been solved:

1) Circular plate under laterial load and edge compression non-linear strain hardening creep.
2) Circular plate loaded into plastic range under lateral load and edge compression.
3) Bending of rectangular plate with non-linear straing hardening creep.

Our future plan will be the analyses of inelastic rectangular plates under both laterial load and edge compression which are of great practical interest. We are currently analyzing the plastic bending of rectangular plate without edge compression.

EFFECTS OF PROTON BOMBARDMENT ON MATERIALS FOR SHIELDING AGAINST SOLAR FLARES

J. P. Frankel   Account No. 448604

An ultrapure aluminum target specimen was bombarded with 12.5-Mev deuterons for 300 μA·h. The specimen was sufficiently

thick so that all the hydrogen was trapped within it. At no time did the temperature exceed 300° F.

X-ray diffraction studies of the specimen indicated the formation of a new phase with the hexagonal structure predicted for aluminum hydride and d spacings which coincide with those given for aluminum hydride in the literature. Least-squares analysis of 21 diffraction peaks shows a hexagonal structure with c/a = 1.57 $\pm$ 0.05, c = 4.55 $\pm$ 0.08 Å, and a = 2.90 $\pm$ 0.05 Å.

This project has now been completed.

RESEARCH IN MOLECULAR RELAXATION PROCESSES AT LOW TEMPERATURES

E. L. Knuth   Account No. 448604

Professor Knuth received interim support for one month prior to receipt of an NSF grant. Immediate objectives of the project were to measure momentum transfer in particle-surface collisions with incident-particle energies of the order of one electron volt. Results would be applicable to studies of drag of satellites, space vehicles, and meteorites.

DETERMINATION OF THE KNOOP-HARDNESS OF REFRACTORY-METAL SINGLE CRYSTALS

J. P. Neumann   Account No. 448634

The ever increasing temperature requirements of many space vehicles have made the refractory metals, and in particular, molybdenum and tungsten, a primary target of investigations. One of the problems, however, encountered in the use of these metals is their extreme brittleness below room temperature.

This change in the ductility as a function of temperature is possibly related to the active dislocation slip systems. The slip systems, on the other hand, will determine the Knoop-hardness of single crystals at room temperature.

The project is a pilot study to investigate the relationship between Knoop-hardness, slip systems, and brittle-ductile transition of molybdenum and tungsten.

FUEL CELL AND CORROSION RESEARCH

K. Nobe   Account No. 448631
F. M. Donahue

The study of iron dissolution in deaerated, acidic solutions is at the same time of practical and fundamental import. On the practical side, the corrosion of materials of construction is an economic waste of material and manpower. Fundamentally, it offers an opportunity to study a rather important generic class of electrode processes, viz. those which involve consecutive electron transfers with adsorption of electroactive intermediates. The anodic dissolution of iron involves the simplest type of this class electroactive intermediate. Therefore, a detailed mechanistic study of this process could be used as a prototype for the study of equally important but more complex processes, e.g., hydrocarbon oxidation (fuel cell applications), inorganic and organic reactants in high energy batteries, and electrolytic synthesis of process intermediates, e.g., adiponitrile, etc.

By utilizing the theory of pseudocapacitance coupled with our knowledge of consecutive electron transfer reactions, it has been possible to estimate the rate constants for all the pertinent kinetic steps for the iron dissolution.

Unfortunately, a quantitative evaluation of the hydrogen evolution reaction (the reduction process occurring during the corrosion of metals in deaerated, acidic solutions) was not possible. Qualitatively, however, it was found to be dependent upon electrode pseudocapacitance (due to adsorbed FeOH), residual stress in the metal, and impurity content of the metal.

A quantitative theory of the structure corrosion inhibition relationship for organic compounds is one of the

more challenging problems facing the corrosion scientist.
As a first step towards this goal, a theory has been
developed and verified by experiment (with substituted
anilines) and by abstracting pertinent data from the
literature. The development is predicated on the use of
linear free energy relationships (LFER), e.g., the Hammett
Relation.

STUDIES IN SPACECRAFT DYNAMICS--Satellite Stability Studies
R. E. Roberson   Account No. 448639
Jens Wittenburg

I. Introduction

In June of 1964 investigations began in the Engineering
Department on the Dynamics of Non-rigid Satellites under the
sponsorship of the Space Science Center, with Professor R. E.
Roberson as principal investigator. These studies have resulted
in what is considered a genuine contribution to the subject, in
the form of a new formalism for the dynamical equations of a
system consisting of an arbitrary number of interconnected
rigid bodies.

Within the scope and fund limitations of the original
study, it has not been possible to explore the implications
of this new formalism. This is primarily because the direction
of the investigations gradually shifted from the original
intent of the principal investigator, and the results
mentioned were obtained only after the bulk of the original study
had been completed. Nevertheless, it is anticipated that
these results will make possible important advances in studies
of the dynamic behavior of complex systems of rigid bodies
of a type particularly interesting for passive attitude
stabilization. But the nature of the problems which can
and should be attacked with this formalism as a tool must
be thought out at some length and much more carefully defined
before it is reasonable to seek separate outside support for
further investigation.

Therefore, it is hereby proposed that the original
study of Spacecraft Dynamics be extended and that supplementary

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funds be granted for this purpose. The specific goal of this extension can be stated concisely as: "To discover some of the practical uses to which this new tool might be put and to define specific problems of practical interest for whose treatment it holds promise." The achievement of this goal, of course, will provide substantial grounds for subsequently seeking outside support for the future prosecution of such problems.

The time period of the proposed extension is 1 June 1965-31 May 1966, the bulk of the work to be done in the period 1 June-1 September 1965. A proposed title for the extended study is "The Dynamics of Orbiting Multi-Body Systems."

It should be unnecessary to dwell here on the implications of the desired results. It should be clear that they will apply to a class of systems which currently are of very great interest and which will remain in the forefront of American astronautical developments for an extended period. It follows that the effort is along lines which have high potential for continued support by the National Aeronautics and Space Administration, with all of the benefits implied by this support to our program of University research and graduate education.

II. Technical Proposal

It is expected that a specific plan of investigation will be defined fully during the period 15 April-1 June 1965. At this time, however, it is possible to remark in general terms on the directions which are felt to be of particular interest and which are likely to be stressed during the summer period.

One question relates to the general problem of existence and stability of equilibrium configurations of complicated systems of bodies. Whether or not the new formalism will materially assist in the treatment of such problems is not yet entirely clear, but preliminary indications are that it may.

Even more confidence can be placed in the applicability
of the formalism to study the transient and steady state be-
havior in small neighborhoods of known equilibria. For the
first time, it may be possible to make some very general state-
ments about such behavior without reference to the specific
configuration of a physical system, but merely with reference
to characteristics of a whole class of systems. For example,
a half dozen or more actual mechanizations have been proposed
in the literature for passively stabilized gravity gradient
satellites consisting of a main vehicle, one or two damping
parts, and perhaps additional parts such as pitch stability
augmentation wheels. It is conjectured that it is possible
to choose parameters for hinge spring and damping torque such
that the dynamic response behavior of all of these systems is
in some sense equivalent. It will be a task of the study to
attempt a rational specification of equivalence in this sense
and to explore the possible truth of the conjecture. If results
can be gotten on this problem, it will have sweeping implica-
tions to the practical design of passively stabilized systems:
it will mean that the specifics of a configuration design
should be determined solely by physical design convenience or
by operational factors other than those relating to the dynamic
response of the vehicle, since effectively the same response
can be obtained by any of a large class of systems.

Undoubtedly other possible problems will present them-
selves as further thought is given to the question. At the
moment, the ability to deal with such complex systems outside
a very specific choice of vehicle structure is so new that
not all of its implications have been appreciated.

Professor Robert E. Roberson was assisted in his research
by Mr. Jens Wittenburg.

STUDIES OF THE DYNAMICS OF NON-RIGID SATELLITES
R. E. Roberson   Account No. 448640

As originally proposed, this investigation was intended
to be directed solely toward satellites dynamically modeled as

orbiting continuum. During its course, the focus gradually
shifted because of literature directly applicable to the pro-
posed problem, which increased the requirements for background
study and preparatory spade work far beyond the level originally
contemplated by the principal investigator. A second pressure
arose from the high level of current interest in practical systems
consisting of large numbers of interconnected rigid bodies.
A system of the latter type is certainly non-rigid, and falls
within the scope of the study even though it is not precisely
the type originally contemplated.

During the investigation, therefore, attention turned in-
creasingly toward the problem of sets of rigid bodies. The
foundations of this subject were previously well established,
and practical techniques for treating them existed for systems
consisting of two rigid bodies. The basic techniques for the
dynamic simulation in this special case were best outlined by
Fletcher, Rongeved, and Yu in their well-known paper "Dynamics
Analysis of a Two-Body Gravitationally Oriented Satellite,"
Bell System Tech.J., 42 (1963), 2239-2266. However, analogous
techniques for more complicated systems of bodies had not been
developed, and it was recognized generally that the mathematical
formalism necessary to treat more complex systems in a sys-
tematic fashion would be rather complicated, even though based
upon known principles. The principal investigator set himself
the problem of developing such a formalism.

These efforts have been entirely successful. An inter-
connected set of rigid bodies of almost completely general
structure has been considered, subject thus far to only two
limitations: First, the structure of the interconnection is
limited to a topological tree (which covers almost every
situation of practical interest); second, it is required that
each contiguous pair of bodies have a common point. The
latter requirement rules out only situations in which con-
tiguous bodies are free to wander away from one another as in
the TRAAC type gravity gradient attitude stabilization method.
Thus the second requirement does limit the generality of the
results to a modest degree, but the formalism which has been
developed has a good prospect for later generalization to

cover this exceptional case. The results of the work are now being incorporated into a paper, "Dynamical Formalism for an Arbitrary Number of Interconnected Rigid Bodies, with Reference to the Problem of Satellite Attitude Control."

The identical problem has been attacked in the meantime by W. Hooker and G. Margulies of the Philco Corporation, with whom the principal investigator has worked closely, and closely comparable results have been obtained by them. However, the methodology and viewpoint used in the construction of the formalism by those investigators and by Roberson in the present study are quite different and serve to illuminate the problem from distinct points of view. There seems no doubt that their results are independently publishable. The essence of Roberson's approach is to establish at the outset a connection matrix for the system, a matrix which establishes a relationship between the enumeration of constituent bodies and the enumeration of common points between bodies. In conjunction with the intro-duction of certain matrices whose components are themselves vectors of dyadics, the connection matrix permits a simple and compact approach to the otherwise chaotic elimination problems which beset any attempt to reduce the dynamical description to a purely rotational set of variables.

The consequences of the newly developed formalism have not yet been explored, and it is not expected to be able to explore them during the term of the existing study sponsored by the Space Science Center. It is felt, however, that the ability to represent the dynamical description of extremely complicated systems of bodies within the framework of such a simple formalism will make it possible to attack problems of great practical interest which heretofore have been obscured by the sheer mass of notation required for their description.

FLUID MECHANICAL PROPERTIES OF LOW DENSITY GAS FLOWS

N. Rott   Account No. 448638
C. Y. Kiu

Dr. M. Oberai's article on the shock-wave structure in a binary mixture has been published in the May 1965 issue of

Physics of Fluids. He has, since the date of submission of
the last report, completed a report entitled "Kinetic Theory
Approach to the Study of a Curved Shock-Wave." This study is
an extension of Mott-Smith method to the problem of shock-
wave in a flow at relatively low Reynolds number so that the
shock-curvature and shock-thickness effects have to be taken
into account. The report includes zero-order shock structure,
discussion on the role of arbitrary additive constant in the
zero-order solution, modified shock-conditions, and the solution
of the first-order shock structure. It was originally published
as Department of Engineering (UCLA) report No. 65-27 and has
now been brought out by NASA as TN 2858. Dr. Oberai has also
set up a criterion for determining the Mott-Smith distribution
which best (in the sense of the least square method) approxi-
mates solution of a kinetic equation. He proposes to give
explicit calculations for the case when the Mach number is
infinite. As his appointment with NASA has been terminated, this
study will be completed and published at a later date.

FILAMENT-MATRIX STRUCTURES

M. F. Rubinstein   Account No. 448643
R. McKee

Structures made up of filaments embedded in a matrix of
lower strength (such as reinforced concrete) often have much
better mechanical properties than either component alone.
The purpose of this research is to improve our knowledge of the
cause of these improvements.

An examination of literature in the field has shown that
the strength of fine filaments (particularly glass filaments)
and some of the elastic properties of simple composites can
be adequately explained by current theories. However, no
satisfactory model has been synthesized for the fracture stress
of the simplest kind of composite-parallel, closely packed
fibers in a soft matrix. The fracture stress for such com-
posites lies between that corresponding to a loose bundle of
filaments and the average of the fracture stresses of the
individual filaments. In the former model, each fiber breaks

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at its weakest point, until the remaining fibers can no longer support the load. A probabilistic model for fracture is being developed, with experimental support, to agree with the observed fact that fracture paths run partly through fibers and partly on the interface between fiber and matrix.

This model deals with the distribution of weakest points in the fibers, and attempts to describe the stress distribution surrounding a singularity in a non-homogeneous medium.

DEVELOPMENT OF FAR INFRARED TECHNOLOGY
T. F. Tao   Account No. 448644

Brief Description of This Study

By far infrared, we are referring to the electromagnetic waves in the spectrum between the microwave and infrared. The energy of the radiations in this spectrum available today is extremely weak. The success of a study depends very much on the availability of an ultrasensitive detector. In the last decade, several low temperature detectors have been developed which allowed considerable progress in this field. Most of these detectors are bolometers which have relatively slow response time of the order of milliseconds. There are several fast-response quantum photodetectors using doped semiconductors which can detect waves of wavelength up to one or two hundred microns. At longer wavelengths, there exists only one photodetector, the Putley detector which is made of a high purity n-type InSb, cooled below 4.2° K and subjected to a magnetic field.

This study tries to use the energy gap of a superconductor (of the order of zero to 10^{-3} e.v.) to detect radiations from 100 micron up to three or four thousand microns. Its response time should be of the order of microseconds.

Progress

During the last period, the following progress has been made:

1. Low Temperature Facilities: The Roots blower arrived in April. The helium cryostat system is now completed

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and tested. The total pumping capacity is approximately 320 cfm. With moderate helium evaporation, the lowest temperature reached is $1.02°$ K.

2. Thin Film Facilities: We have added a Sloan microbalance to measure the thickness of thin film during evaporation.

3. Far Infrared Facilities: The optical design of a Czerny-Turner grating monochromator was completed around April. Construction by our own machine shop was started and is still continuing.

Current Projects

Three projects are in progress.

1. Continuation of monochromator construction.

2. Study of the I-V characteristics of both the semiconductor-superconductor junctions and semiconductor-insulator-superconductor sandwiches. They are the preliminary studies before we develop the superconducting photodetector.

3. Conventional Czerny-Turner monochromator uses two identical spherical mirrors. Our design also adopted this arrangement. This summer, we are studying if two ellipsoidal mirrors can be used to reduce the astigmatism.

SPIN-LATTICE RELAXATION TIME MEASUREMENT IN LASER-MASER MATERIALS

C. R. Viswanathan   Account No. 448646

The project concerns itself with study of the spin-lattice relaxation process in paramagnetic materials that are used in lasers and masers. The objective is to understand better the relaxation process and also to search for new laser-maser materials.

The relaxation time is measured by two independent methods: Microwave signal method and optical detection method. The overall experimental arrangement is comprised mainly of magnet system, cryogenic system, microwave system, electronic

system, and optical system.

A Varian 8-inch electromagnet was modified for use
in this project. At the present time homogeneity measurements
are being made. Some tests have been made on the overall
stability of the magnet as well as that of the magnetometer
that is used for measurement of the magnetic field.

In order to achieve low temperature it is necessary not
only to house the sample in a helium dewar but also to pump
on the helium to obtain temperatures lower than the boiling
point of helium. A special dewar was designed in which the
sample could be housed inside a microwave cavity and also op-
tically illuminated. A control panel to regulate the pumping
speed and to read the temperature of the sample has been
fabricated. The whole system has been tested and found to
be satisfactory.

Microwave and optical system components have been
obtained, as well as those for the electronic system. The
relaxation time measurement will be carried out by photo-
graphing the signal trace on the screen of the oscilloscope.

The chemicals for growing the crystal samples have
been obtained. The magnetic homogeneity measurement is being
completed and microwave, and electronic systems have been
interconnected and some crystal samples grown.

Measurements of the spin-lattice relaxation time
of various samples under various experimental conditions will
comprise the remainder of the project.

CAPILLARY-PRESSURE AS FUNCTION OF LIQUID SATURATION
IN POROUS MEDIA
W. D. Van Vorst   Account No. 448648

Capillary-pressure gradients in porous media may offer
a means of controlling fluid flow in a gravity-free environment.
In energy conversion cycles involving two phases (such as
condensers and boilers), the gravitational force is relied upon
to effect the desired separation. Where this force is neg-
ligible, other means must be sought, and the behavior of

liquids in capillaries may make such separations possible and
practical. Knowledge of the capillary pressure will be of prime
importance.

An experimental investigation of capillary pressure
relationships in porous media has been undertaken. It is
felt that the gamma ray attenuation technique can be employed
to determine the liquid saturation. The capillary pressure
per se can be determined using a drainage technique which
is equivalent to measuring the "capillary-rise" in a capillary.
Particle size of the porous medium and surface tension of the
liquid will be varied substantially, and a correlation of the
capillary pressure, particle size, and surface tension sought.

MASS TRANSFER COEFFICIENT

A. R. Wazzan   Account No. 448637

A paper entitled "Mass Transfer Method of Measuring
Wall Shear Stress" is to be published in the <u>Journal of
Physics of Fluids</u>. Authors are A. R. Wazzan, M. S. King, and
A. Almediah. The abstract follows.

Abstract

Dilatational wave velocities in Ni-Mn alloys are measured
at $25°C$ in the composition range 0 to 80% manganese using
ultrasonic pulse techniques. Using a value of 1/3 for
Poisson's ratio in the alloys, the observed values for the
velocities are used to compute the corresponding values of
the dynamic elastic moduli E. The dilatational wave
velocities, ranging from 5638 m/sec in nickel to 3792 m/sec
in the alloy with 80% Mn and the corresponding elastic
moduli, ranging from 19350 to 7570 Kg/mm^2, are found, almost
linearly, to decrease with increasing manganese content
over the composition range 0 to 40% Mn; to increase over
the range 40 to 50% Mn; and then to decrease again over the
range 50 to 80% Mn. The increase in the elastic modulus
with % Mn over the range 40 to 50% Mn is associated with the
formation of the highly ordered NiMn (δ) phase with a bcc
crystal structure. The variation of V and E with % Mn in
the range of 60 to 80% Mn is found to be an extension of

their variation in the range 0 to 40% Mn. This variation where the Young modulus of nickel decreases at an average rate of 125 Kg/mm^2 per atomic percent manganese added is characteristic of the solid solution γ phase. At the tests' temperature, 25°C, the alloys with up to 25% Mn are in the ferromagnetic state, whereas the alloys over the composition range 25 to 80% Mn are in the paramagnetic state.

Dr. Wazzan has also been studying the effect of plastic deformation on diffusion in nickel. The results have been published in the Journal of Applied Physics, 36, 1, 222-229, January 1965. As a continuation of this project, he plans to study the effect of para to ferromagnetic transition on the activation energy for self-diffusion in nickel, as out-lined in the following abstract:

Recent measurements of diffusion in metals with ferro-magnetic properties indicate that the diffusion coefficient of the metal in the ferromagnetic state is different from that of the metal in the paramagnetic state. This anomaly in diffusivity is associated with a change in the frequency factor and/or in the activation energy for diffusion. Thus far the latter seems to give the more plausible explanation. It is proposed here to study self-diffusion of radioactive nickel 63 into high purity ferro and paramagnetic nickel and to determine the activation energy for self-diffusion in each of the two states. An attempt will be made to compare the difference between these two activation energies with the theoretically predicted energy of magnetic interaction in nickel. This work is of great importance for both scientific and engineering purposes as it is closely related to determining the mechanical properties of nickel at low temperatures.

VISITING LECTURERS

A. Papoulis   Account No. 448604

During the academic year 1964-65, Dr. Athanasios
Papoulis, Professor of Electrical Engineering at the Poly-
technic Institute of Brooklyn, was appointed Visiting Pro-
fessor and Research Engineer in the Department of Engineering.
Dr. Papoulis is noted as an outstanding contributor in the
area of network synthesis and linear systems analysis, and he
continued in this vein while at UCLA. Many members of the
faculty and staff and graduate students were aided by this
distinguished scholar through his teaching and research
activities.

He taught Circuit Analysis Using Transform Methods during
the fall and spring semesters, along with Passive Network
Synthesis in the fall and Advanced Circuit Theory in the
spring. He completed a book entitled <u>Probability, Random
Variables, and Stochastic Processes</u>. He also published nine
separate papers on such topics as: "The Meaning of Prob-
ability," "Sensitivity Analysis with Random Increments,"
"Systems with Stationary Inputs," and "Wide-Sense Markoff
Sequences and Recursive Filtering." In addition to his
publications he has been active in the areas of Random Error
Analysis in the Numerical Solution of Differential Equations
and on Stochastic Differential Equations.

COMMUNICATIONS RESEARCH LABORATORY

R. A. Stampfl   Account No. 448604

Laser Communication

The purpose of this project is to conduct experiments
in Laser Communication using phase modulation and a phase locked
loop for detection. The construction of the system proceeded
along the lines reported previously. To this date, successful
sinusoids and audio modulation has been accomplished, and
the equipment operates stable and repeatable.

As can be seen from the attached Fig.1, a signal beam
and local oscillator beam are generated by a conventional

beam splitter. A mirror can be deflected over small distance by application of voltage to a piezo electric crystal carrying the mirror, one being used as phase modulator, the other as the phase compensator in the L. O. beam. The diverging lens following the beam combiner serves to ease adjustment of a fringe pattern. The small aperture permits detection of intensity modulation due to variation in the fringe position when modulation is applied. Because of the frequency response of the piezo electric crystals given in Fig.2, direct audio modulation is impractical. Many resonance peaks can be found, one with high sensitivity lying at 58 Kc so that subcarrier A-M is feasible. The low frequency noise due to mechanical deflection and phase distortion in the signal beam over long transmission paths is compensated for in the phase locked loop by the second mirror. A loop amplifier has been built using standard Philbrick D. C. amplifier modules. Frequency and phase response are given in Figs.3 and 4, and a schematic diagram in Fig.5.

Measurement of the loop response is exceedingly difficult because mechanical vibration constitutes a high noise level. Closed loop operations yielded good transmission quality. The amplifier has adjustable gain from 0-100 and contains a variable bias source to compensate for the PMT D.C. component and to adjust the fringe position. Gain setting was arrived at empirically and is not critical if the bias adjustment is made carefully. The loop response is essentially that of the loop amplifier.

Separation of the modulator from the common mounting plate was attempted but failed due to inadequate component availability of an optic system for the signal beam and further because the shock mounting of the remote apparatus was introduced. These are the apparent areas of future improvement to permit additional experimental evaluation.

MICROPHONE

SIG. GEN. 5.8Kc

AMPL. MOD.

PHASE MODULATED (MIRROR)

LENS   BEAM SPLITTER

SIGNAL BEAM

HE-NE LASER

L.O. BEAM

BEAM COMBINER

PMT

BAFFLE

APERTURE

LENS

BIAS

5.8 Kc Filter

DEMODULATOR

AMPLIFIER

FIGURE   1

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PIEZOELECTRIC CRYSTAL FREQUENCY RESPONSE

FOAM RUBBER MOUNTING
APPLIED VOLTAGE: $1.0 \sin(2\pi f t)$ VOLTS

PEAK TO PEAK DEFLECTION - MICRONS

FREQUENCY - CPS

GRAPH

PLOTTING AMPLIFIER GAIN vs. FREQUENCY

FREQUENCY (CPS)

GAIN (db.)

GRAPH

PLOTTING AMPLIFIER PHASE SHIFT
vs
FREQUENCY

FREQUENCY (CPS)

PHASE SHIFT

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PMT
(INPUT)

1M

1M

100K

200 K

+300

0.1 µf

200K

-300

100K

1M

300K

+300

BIAS CIRCUIT

1K

0.01 µf

1K

0.01 µf

BIAS CIRCUIT

0.005 µf

1M

1M

BIAS CIRCUIT

1M

0.005 µf

1M

BIAS CIRCUIT

100K

1M

TO CRYSTAL
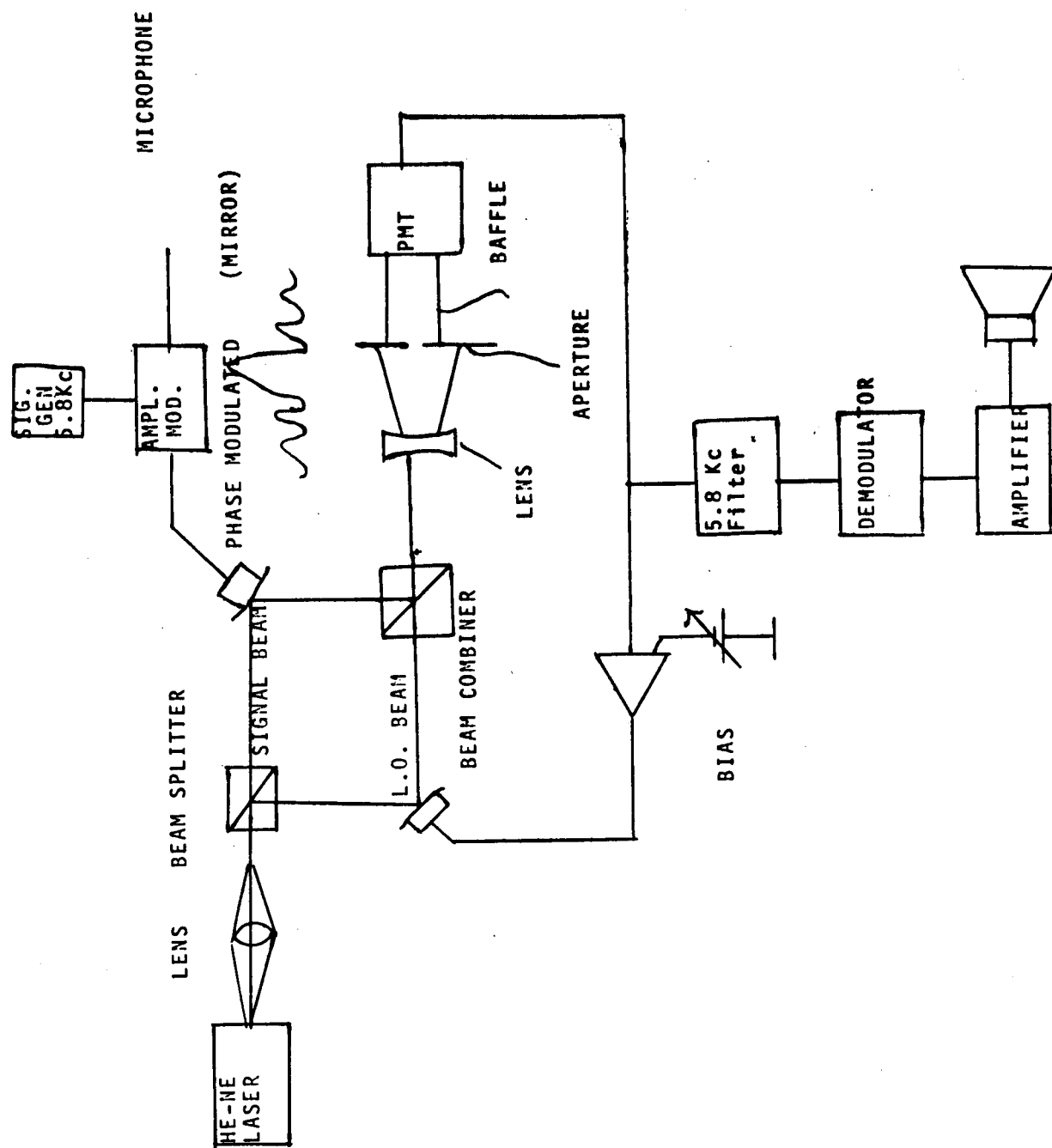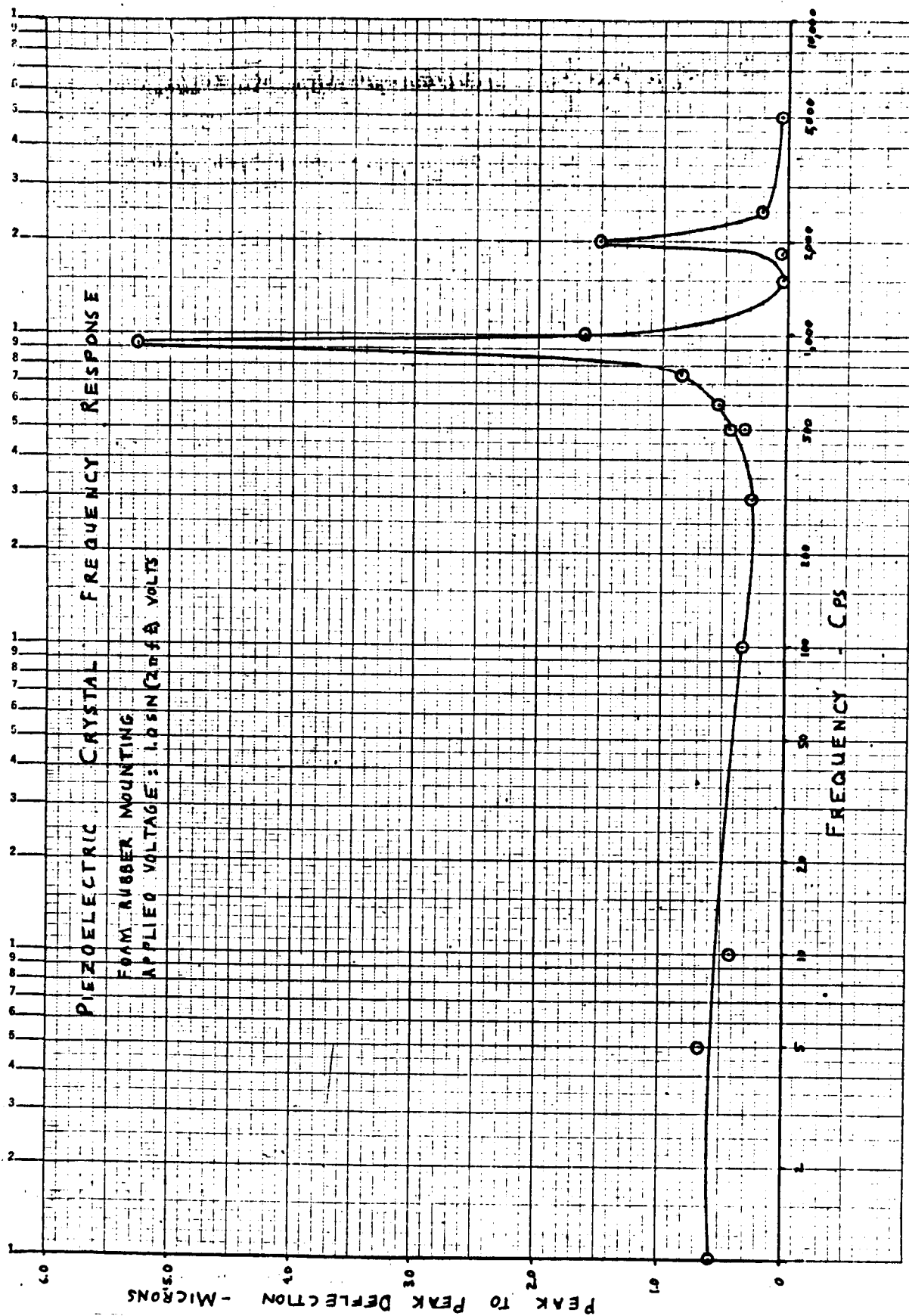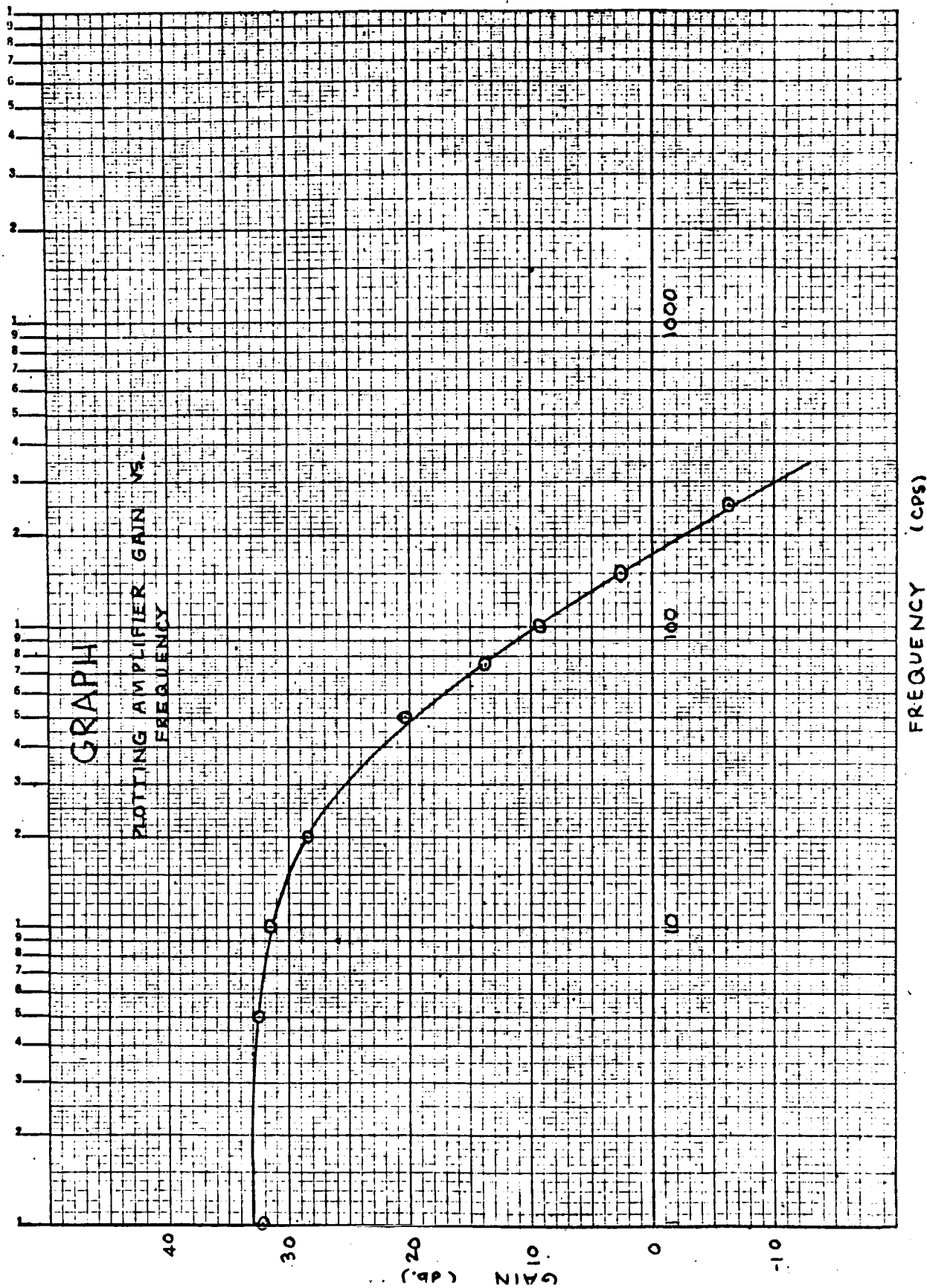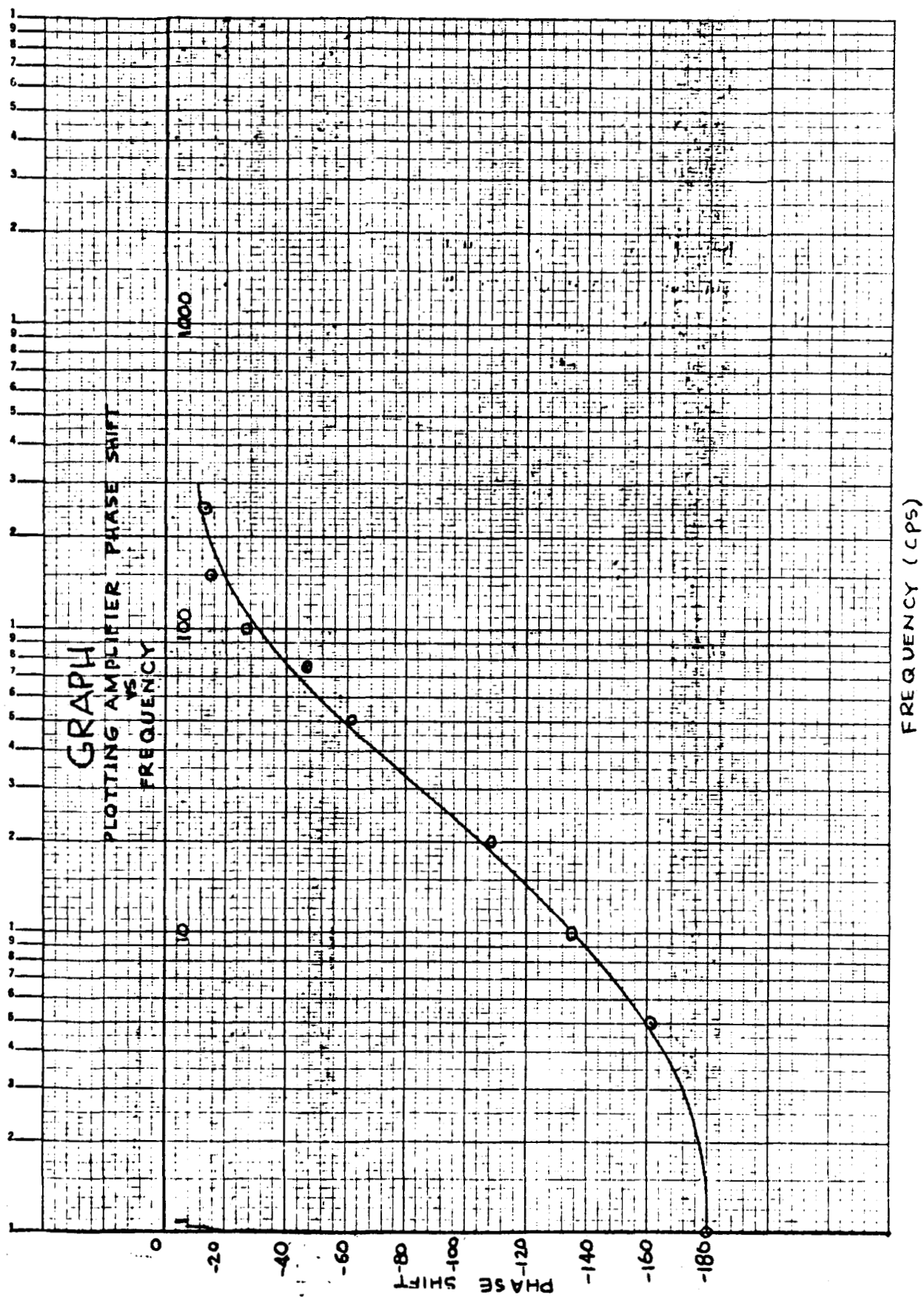(OUTPUT)

BIAS CIRCUIT

* MODULE: MODEL K3-X@

* MODULE: MODEL K3-X@

During the period May to October 1965, Dr. Raimundo O.
Vicente of the Faculty of the Sciences, Lisbon University,
was and is currently with the Department of Engineering. Dr.
Vicente's visit is being devoted to full-time research in the
realm of astronomical and astrodynamical constants.

He has taken advantage of UCLA's excellent library to
begin a study directed at discovering the possibilities of
expressing the basic equations employed in the method of
variation of constants, used in celestial mechanics, in such
a way that it is possible to show they have the same formal
aspects as some equations appearing in hydrodynamics. The
analogies mentioned appeared while he was studying the method
of perturbative differentiation developed by Dr. Samuel
Herrick of UCLA. It appears that investigations along these
lines have not been previously. conducted.

He has also been engaged in researches concerning the
equivalence of the differential equations employed by different
authors in investigations of the precession and nutation, the
free vibrations, and the tides of the solid earth. Several
papers have been published on these subjects employing dif-
ferent systems of coordinates, but an attempt has not been
made to show that the systems of differential equations ob-
tained are equivalent.

The researches mentioned will be developed in the
subsequent months.

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FINANCIAL SUMMARY NsG 237-62

Total Expenditures for Report Period:	$ 352,847
Cumulative Expenditures, March 1962 through February 1965	1,193,446
Additional Commitments* to February 1966:	546,517
Total Expenditures and Commitments through February 1966	$ 2,092,810

*A commitment of NASA NsG 237-62 funds is defined as a firm guarantee of a fixed amount of support to an individual or a group over a limited period of time, usually one year or less. When a commitment is made in the Physical Sciences or Engineering, funds are transferred from the general account to a newly estab-lished special account; control over expenditures from such funds remains with W. F. Libby. Control over expenditures in the Biomedical program remains with J. D. French.

Detailed statements of expenditures for the report period and additional commitments follow.

PERIOD EXPENDITURES

For Six Month Period ending August 31, 1965

Subgrants Account No.	Salaries	Supplies and Expense	Equipment and Facilities	Travel	Total
448604	$ 17,314	$ 8,027	$ -	$ 1,359	$ 26,700
448610	-	89	-	1,342	1,431
448611	-	-	-	-	-
448612	309	145	-	-	454
448619	-	-	33,247	-	33,247
448621	-	1,240	-	-	1,240
448623	7,263	49	-	-	7,312
448624		2,241	4,226	-	6,467
448626	5,706	3,859	2,704	-	12,263
448627	-	-	759	-	759
448628	-	3,390	-	1,749	5,139
448630	4,761	-	-	-	4,761
448631	2,265	-	-	-	2,265
448633	1,465	-	-	-	1,465
448635	794	-	-	-	794
448636	2,815	208	-	-	3,023
448637	3,565	945	-	-	4,510
448638	2,492	-	-	-	2,492
448639	1,571	304	-	-	1,875
448640	1,883	-	-	-	1,883
448641	312	-	-	-	312
448643	1,021	-	-	-	1,021
448644	3,040	229	125	-	3,394
448645	1,665	-	-	-	1,665
448646	2,500	1,429	-	-	3,929
448647	684	-	-	-	684
448649	2,942	-	-	-	2,942
448651	3,220	1,978	2,691	-	7,889
448673	1,031	-	-	-	1,031
448674	1,606	259	-	-	1,865
448675	-	1,712	2,189	-	3,901
Subtotals	$ 70,224	26,104	45,941	4,450	146,720

	Salaries	Supplies and Expense	Equipment and Facilities	Travel	Total
Subgrants	$ 70,224	$ 26,104	$ 45,941	$ 4,450	$146,720
Faculty Summer Salaries	11,844	-	-	-	11,844
Visiting Scientists	8,743	-	-	1,362	10,105
Administration	19,177	2,821	-	514	22,512
Space Biology	22,704	60,694	13,001	-	96,399
Employee Benefits					6,459
Subtotal					$ 294,039
University Overhead					58,808
TOTAL EXPENDITURES FOR THE PERIOD					$ 352,847

ADDITIONAL COMMITMENTS

For Six Month Period Ending February 28, 1966

Subgrants Account No.	Salaries	Supplies and Expense	Equipment and Facilities	Travel	Total
448604	$ 31,733	$ 11,055	$ 10,000	$ 1,350	$ 54,138
448610		1,942	154	350	2,446
448611		68	300		368
448612	300	743		2,395	3,438
448613		330	5,500		5,830
448619			11,432		11,432
448621		1,400			1,400
448623		1,010	3,990		5,000
448624		6,000	3,000		9,000
448626	3,000	1,000	145	600	4,745
448628		38,115	14,387		52,502
448629		1,000	29,000		30,000
448630	2,158	300	665	200	3,323
448632	5,360	1,050	1,315	350	8,075
448634	2,657	1,290			3,947
448636	484	351		500	1,335
448637	2,266	7,164			9,430
448639	1,192			227	1,419
448640	890			235	1,125
448641	1,000	785	1,200		2,985
448642		31,000			31,000
448643	4,685	250	2,000		6,935
448644		641	3,675	200	4,516
448645	543				543
448646	2,857	1,337			4,194
448647	1,871	300			2,171
448648	2,150	100			2,250
448649		4,547			4,547
448651	1,385	1,000	672	290	3,347
448674		569			569
448675	2,420	3,488	3,611	2,900	12,419
448676	4,700				4,700
Subtotals	$ 71,651	$116,835	$ 91,046	$ 9,597	$289,129

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ADDITIONAL COMMITMENTS - continued

	Salaries	Supplies and Expense	Equipment and Facilities	Travel	Total
Subgrants	$ 71,651	$ 116,835	$ 91,046	$ 9,577	$289,129
Faculty Summer Salaries	-	-	-	-	-
Visiting Scientists	15,000	-	-	2,500	17,500
Administration	20,000	3,000	-	500	23,500
Space Biology	31,917	15,028	66,000	-	112,945
Employee Benefits					12,357
Subtotal					$ 455,431
University Overhead					91,086
TOTAL					$ 546,517